

N83447.AR.000322
NAS FORT WORTH
5090.3a

CORRECTIVE ACTION PLAN ATTACHMENT 20 ASSESSMENT REPORT FORM FOR BASE
GAS STATION NAS FORT WORTH TX
6/1/1997
INTERNATIONAL TECHNOLOGIES

329 0



**NAVAL AIR STATION
FORT WORTH JRB
CARSWELL FIELD
TEXAS**

**ADMINISTRATIVE RECORD
COVER SHEET**

AR File Number 329

File:
A.F. 17A-57

329³²⁹
1

**Corrective Action Plan
Attachment 20, TNRCC Assessment Report Form
Base Gas Station
Naval Air Station Fort Worth
Joint Reserve Base, Carswell Field
Fort Worth, Texas
LPST ID No. NA
Facility ID No. 009696**

Prepared for:

**Air Force Center for Environmental Excellence
Brooks Air Force Base, Texas
Contract No. F41624-94-D-8047
Delivery Order No. 0032**

Prepared by:

**IT Corporation
312 Directors Drive
Knoxville, Tennessee 37923**

**Project No. 765725
Revision 0**

June 1997

**ATTACHMENT 20, TNRCC ASSESSMENT REPORT FORMS,
BASE GAS STATION
PROPOSAL FOR NEXT APPROPRIATE ACTION
AND/OR SITE CLOSURE REQUEST**

Table of Contents

	<i>Page</i>
List of Figures	iv
List of Acronyms	v
1.0 Introduction	1
2.0 Background	1
3.0 Next Appropriate Action	1
4.0 Groundwater Sampling and Analysis Procedures	2
4.1 Groundwater Analytical Methods	2
4.2 Groundwater Sampling Procedures	2
4.3 Water Level Measurements	3
4.4 Groundwater Sample Collection	4
Enclosure 1 - Plan B Risk Assessment, Base Service Station	

List of Figures

Number	Title	Follows Page
4-1	Base Gas Station Monitoring Wells	2
8-1	Surrounding Land Use	8-7
8-2	Summary of Numerical Pathway Analysis Assessment Report	8-11

List of Acronyms

AFB	Air Force Base
AFCEE	Air Force Center for Environmental Excellence
BTEX	benzene, toluene, ethyl benzene, and xylene
°C	degrees Celsius
EPA	U.S. Environmental Protection Agency
gal/ft	gallons per foot
IT	IT Corporation
JRB	Joint Reserve Base
lpm	liter per minute
mg/L	milligram per liter
mL/min	milliliter per minute
MTBE	methyl tertiary butyl ether
NAPL	nonaqueous-phase liquid
NAS	Naval Air Station
NTU	nephelometric turbidity unit
pH	power of hydrogen
TNRCC	Texas National Resources Conservation Commission
VOC	volatile organic compound

1.0 Introduction

IT Corporation (IT) conducted a review in August 1996 of available historical soil and groundwater data from several investigations and removal activities that occurred from 1992 to 1996 at the Base Gas Station located at Naval Air Station (NAS) Ft. Worth Joint Reserve Base (JRB), Carswell Field, Ft. Worth, Texas, from 1992 to 1996. This data was reviewed and consolidated under contract with the Air Force Center for Environmental Excellence (AFCEE) Brooks AFB, San Antonio, Texas, for a TNRCC Plan A assessment. This document forms Attachment 20 of the *TNRCC Assessment Report Form, Base Gas Station* (March, 1997).

2.0 Background

The results of this investigation were included in the *NAS Fort Worth Assessment Report*, (January 1997), prepared for and submitted to AFCEE as Appendix Q entitled *TNRCC Assessment Report Form, Base Gas Station*. This latter assessment report includes the TNRCC Plan A assessment forms and was issued March, 1997. The findings of this investigation indicated concentrations of benzene in the soil and groundwater that exceed the TNRCC Plan A criteria. IT therefore completed a Plan B assessment of the Base Gas Station using chemical analytical data and on geotechnical data gathered by the USACE in 1993. The Plan B assessment is the Section 8.0, Risk Assessment, in the *NAS Fort Worth Assessment Report*, (January, 1997), and is included in this Corrective Action Plan as Enclosure 1.

3.0 Next Appropriate Action

The results of the Plan B cumulative baseline risk assessment for the on-site and off-site exposure pathways indicate there is no unacceptable human health risk for the current or future exposure pathways. No further action is recommended at this site except monitoring.

Quarterly groundwater monitoring for a period of one year is recommended. The third quarter sampling round may be eliminated if the characteristics of Rounds 1 and 2 are consistent with the results of the previous sampling. The fourth quarter sampling round will be completed regardless. The groundwater samples are to be analyzed by EPA Method SW8020 for BTEX compounds and MTBE. Three wells (BGSMW03, BGSMW05, and BGSMW06) should be

monitored for COPCs during the quarterly monitoring. Monitoring results will be used to verify groundwater contaminant levels are stable and confirm human health exposure assumptions.

Provided that monitoring results verifies and confirms objectives a request for closure at the Base Service Station site will be transmitted by the Air Force to the TNRCC.

4.0 Groundwater Sampling and Analysis Procedures

The collection of groundwater samples from designated monitoring wells at the Base Gas Station will be performed on a quarterly basis for one year (four sampling events) to obtain data on the groundwater constituent stability at the site. This section provides the methods and procedures recommended for the sampling and analysis of groundwater collected from the monitoring wells BGSMW03, BGSMW05, and BGSMW06. The location of the monitoring wells to be sampled are shown in Figure 4-1.

4.1 Groundwater Analytical Methods

The groundwater samples will be submitted for analysis by EPA Method SW8020 for BTEX compounds and MTBE.

Groundwater field parameters will be measured during collection of samples from the monitoring wells. Parameters to be measured in the field and the recommended methods include pH (SW9040), temperature (EPA 170.1), conductivity (EPA 120.1), dissolved oxygen (EPA 360.1), and turbidity (EPA 180.1).

4.2 Groundwater Sampling Procedures

Groundwater samples for laboratory analysis are to be collected from designated groundwater monitor wells at the Base Gas Station located at NAS Fort Worth. Groundwater sample collection procedures will follow standard procedures outlined in this section. Low flow groundwater sampling techniques will be utilized to collect samples from groundwater monitoring wells .

The air in the breathing zone will be checked with a PID each time a well cap is removed prior to monitoring well activity. Each well shall be inspected for signs of tampering or other damage. If tampering is suspected, it will be noted on the sampling form, and reported to the designated

LEGEND:

- MONITORING WELL LOCATIONS
- ▨ OPEN DRAINAGE DITCH
- () NEW NAVY STREET NAME

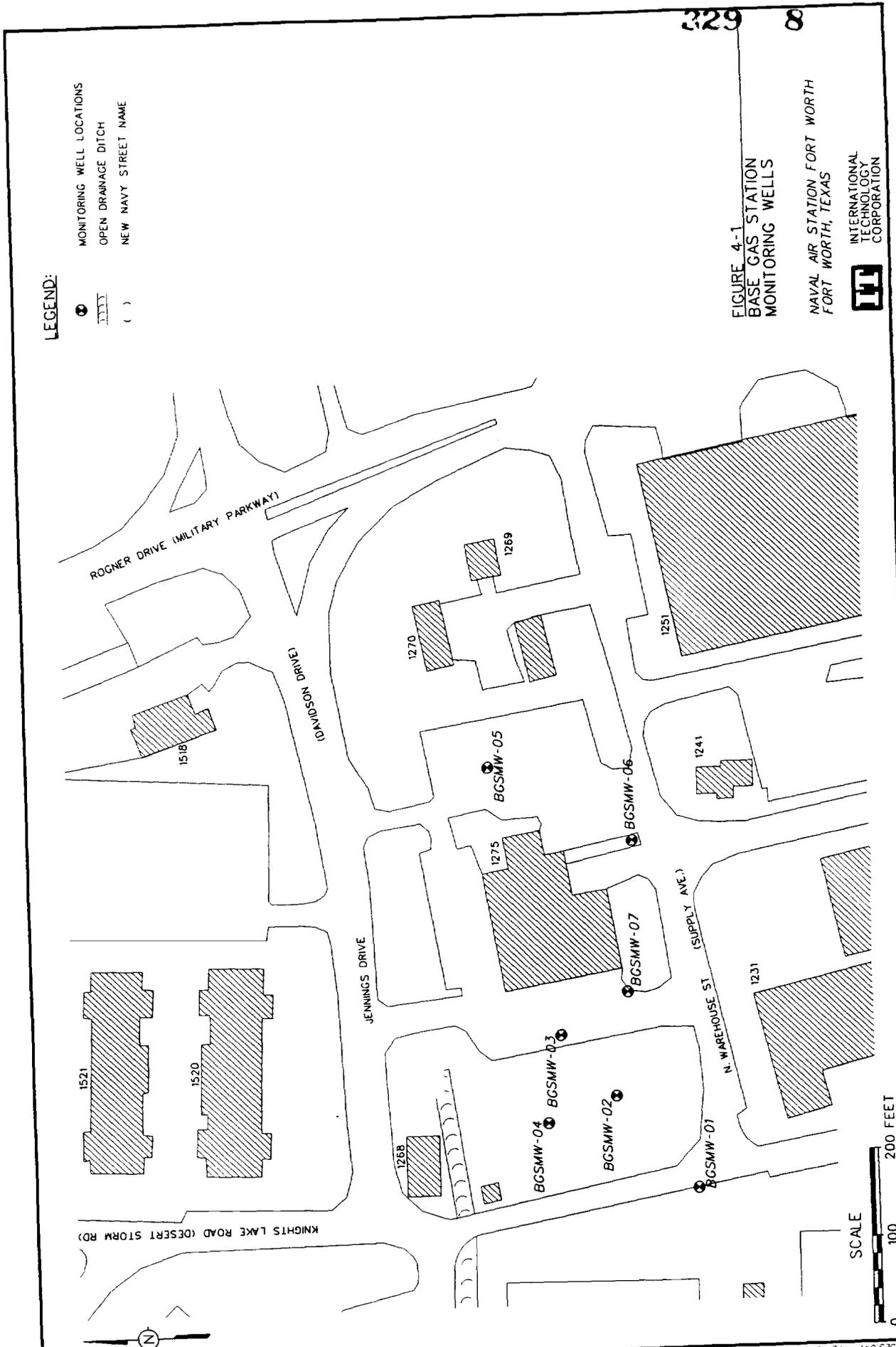


FIGURE 4-1
BASE GAS STATION
MONITORING WELLS

NAVAL AIR STATION FORT WORTH
 FORT WORTH, TEXAS



INTERNATIONAL
 TECHNOLOGY
 CORPORATION

STARTING DATE: 6/12/97	DRAWN BY: R. KNIGHT	ENGR CHK BY: W. CARTER	PROJ MGR: W. CARTER	DWG NO: 7657255.047
DATE LAST REV:			INITIATOR: W. CARTER	

76572555.047 11:21:16 JUNE 13, 1997 RMK

Air Force representative. Wells that are suspected to have been tampered with will not be sampled until the matter has been cleared by the designated Air Force representative. Each well will be measured with an interface probe to collect water level data and to check for and measure light nonaqueous-phase liquid thickness. The field geologist will calculate the volume of water in the well and the three well bore volumes of groundwater needed to purge the well.

Before the start of sampling activities, plastic sheeting will be placed on the ground surrounding the well. Water standing in the well protective casing must be removed before opening the well cap. Well purging will consist of evacuation of water until the groundwater has little visible turbidity (i.e., is clear) and the groundwater parameters (temperature, pH, and conductivity) have stabilized as defined in the following paragraphs. Purging and sampling of the wells will be performed in a manner that minimizes agitation of sediment in the well and formation. Equipment will not be allowed to free fall into the well.

The following information shall be recorded each time a well is purged and sampled. The information required is as follows: (1) depth to water before and after purging, (2) well bore volume calculation, (3) total depth of the monitor well as measured with an electronic interface probe, (4) the condition of each well, (5) the thickness of any nonaqueous layer, and (6) field parameters, such as pH, temperature, specific conductance, and turbidity. Adjustments will be made as required to the measurements based on established methods to estimate actual thickness of any NAPL.

4.3 Water Level Measurement

An interface probe shall be used if a nonconductive non-aqueous phase liquid is suspected in a monitoring well. The interface probe shall be used to determine the presence of light or dense non-aqueous phase liquid, if any, during measurement of the groundwater level. Hydrocarbon detection paste, or any other method that may affect water chemistry, shall not be used. When detected, the presence of NAPL materials shall be confirmed by withdrawing a sample with a clear, bottom-fill bailer.

Water levels will be measured from the top of monitor well casing and recorded on the well sampling form. If well casings are not notched, measurements will be taken from the north edge of the top of the well casing, and a notch will be made with using a decontaminated metal file. Following water level measurement, the total depth of the temporary well point or monitoring well from the top of the casing will be determined using the electric water level indicator or the interphase probe (monitoring well) and recorded on the well sampling form. The water level

depth will then be subtracted from the total depth of the well to determine the height of the water column present in the well casing. All water level and total depth measuring devices shall be routinely checked at least annually with a tape measure to ensure measurements are accurate.

The volume of a 1-foot section of the well borehole (F) can also be calculated using the formula:

$$F = \pi(D/2)^2 \times 7.48 \text{ gal/ft}^3$$

where:

$$\pi = 3.14$$

D = the inside diameter of the well borehole in feet.

4.4 Groundwater Sample Collection

Before collecting groundwater samples, the sampler will don clean, phthalate-free protective gloves.. From monitoring wells, VOC samples will be collected first using disposable clear polyethylene tubing discharging directly into the sample container. Low flow sampling will use small positive displacement pumps. Samples to be analyzed for volatile or gaseous constituents will not be withdrawn with pumps that exert a vacuum on the sample. Polyethylene tubing used for sample collection will be used once and then disposed of.

The sampler will establish a pump flow rate to minimize groundwater head drawdown low flow groundwater sampling procedures. After the flow rate is established, the sampler will monitor groundwater parameters of temperature, pH, dissolved oxygen, and conductivity and record the measurements on a groundwater sample collection log (Appendix A). Low flow sampling procedures will be conducted by the following methods:

- The sampling pump should be installed at the same depth in each well. Moderate sustained well yields of 5 gpm are common and pumps will be set in the upper third of the saturated well screen due to low expected drawdown. If low yielding wells are present in an area, then the pump should be positioned towards the bottom one-third of the saturated well screen.
- A pumping rate that minimizes drawdown in the well will be established. Initial purge rates will begin at 0.2 liter per minute (lpm). If the well drawdown is very low, the purge rate may be increase to up to 2.0 lpm. Well drawdown should not exceed one-third of the water column.

- A minimum of three casing volumes of water have been removed from the well.
- Field measurement of the groundwater turbidity is within 5 NTUs over three consecutive readings or consecutive turbidity readings below 10 NTU are attained.
- Field measurement of the water for pH is within 0.1 standard unit of the previous reading.
- Field measurement of the water specific conductivity is within 5 percent of the previous reading.
- Field measurement of the water temperature is within 1°C of the previous reading.
- Field measurement of the dissolved oxygen is within 0.3 mg/l of the previous reading.
- Once the parameters stabilize and the purge is complete, the flow rate will be reduced to 100 ml/min before collecting the groundwater sample.

If the parameters do not stabilize, the sample will be collected after six well volumes have been removed, and the anomalous parameters brought to the designated Air Force representatives attention. All field measurements of groundwater collected by low flow methods will be made with the instrument probes submerged in a flow cell.

An initial groundwater sample will be collected at least 24 hours after completion of monitoring well development. Subsequent samples may be collected when scheduled. A groundwater sample may not be collected until three well bore volumes have been removed and the temperature, pH, and conductivity have stabilized. The sample will then be collected immediately after the water level has recovered to 80 percent of its static level or 8 hours after completion of purging, whichever comes first.

VOC sample bottles will have been prepared by the laboratory with hydrochloric acid preservative. The sample will be collected from the sampling device by pouring the collected groundwater down the side of a tilted sample vial to minimize volatilization. The sample vial will be filled until a meniscus is visible and immediately sealed. When the bottle is capped, it will be inverted and gently tapped to ensure no air bubbles are present in the vial. Vials with trapped air will be refilled until no bubbles are present in the vial. These samples will never be composited, homogenized, or filtered.

Following collection of VOC samples, the pH of preserved sample will be checked by pouring a small amount of a non-VOC water sample onto pH paper. The paper will not touch the inside of the container. The preservation checks will be documented in the chain-of-custody forms. One preserved VOC sample a day that will not be submitted for laboratory analysis will be checked with pH paper to verify proper preservation.

ENCLOSURE 1

**PLAN B RISK ASSESSMENT
BASE GAS STATION**

(This Risk Assessment has been extracted from Section 8.0,
NAS Forth Worth Assessment Report, January 1997)

8.0 Risk Assessment

A baseline risk assessment was conducted for both the Base Gas Station and Base Service Station in accordance with TNRCC guidance (RG-36, TNRCC, 1994a; RG-91, TNRCC, 1994b; RG-175, TNRCC, 1995) relating to risk-based corrective action at petroleum release sites. For both sites, a Plan B risk assessment was performed. A Plan B assessment provides for the use of site-specific data to be employed in assessing risk, rather than the conservative default values employed in a Plan A risk assessment.

As defined by the TNRCC, a Plan B risk assessment considers the transport and fate of the contaminants in soil, air, and water, and potential human exposure under current and future land use conditions. The quantitative risk assessment was performed using a software package called RBCA Plan A/Plan B Spreadsheet System (Groundwater Services Inc. [GSI], 1996), which is specifically designed to calculate baseline risk and site-specific cleanup goals for soil and groundwater constituents based on both site-specific data and site-specific points of exposure (POE). In accordance with the procedures specified in TNRCC Publication RG-36 (TNRCC, 1994a), the software calculates soil and groundwater target levels based upon individual constituent effects at both on-site and off-site POE for soils, air, and groundwater. The user must characterize each on-site receptor as either “current” or “potential future” per TNRCC guidelines. On the basis of these data, the software calculates media cleanup values for both on-site and off-site POE per the modeling procedure outlined in RG-36 (TNRCC, 1994a) and RG-91 (TNRCC, 1994b).

8.1 Identification of Chemicals of Concern

Once chemicals attributable to the site are established, the risk-based evaluation further focuses the relevant data set by implementing a screening procedure to define chemicals of potential concern (COPC). This exercise produces a focused characterization of risks attributable to the release of hazardous substances at the site, and enables the determination of clean-up criteria.

Soil and groundwater samples were collected from the Base Service Station and Base Gas Station as described previously in this report. The analytical results for these samples are discussed in Chapters 4.0, 5.0, and 6.0. COPC were determined for the soil matrix and the groundwater matrix for the Base Service Station and Base Gas Station by the use of guidelines outlined in TNRCC’s RG-36 guidance document (TNRCC, 1994a).

The objective of the COPC screening process is to identify chemicals in soil and groundwater at the Base Service Station and the Base Gas Station that contribute significantly to risks calculated for probable soil and groundwater exposure scenarios and to eliminate inappropriate COPC.

8.1.1 Preparation of a Focused Data Set

The analytical data for the Base Service Station and Base Gas Station were prepared for the risk assessment by the use of some techniques that are both conservative in nature (i.e., tend to “overstate” overall risk posed to human health and the environment) and are recognized risk assessment protocols similar to those promulgated in Risk Assessment Guidance for Superfund (RAGS), Human Health Evaluation Manual, Part A (EPA, 1989). Once data were allocated by media (i.e., soil and groundwater), the data were further manipulated in the following manner:

- Data set reported as 100 percent nondetects:
 - Compare sample quantitation limits (SQL) to the applicable Plan A Target Concentrations.
 - a. If the SQL is greater than the Plan A Target Concentration, set the analyte concentration equal to the SQL as a proxy concentration.
 - b. If the SQL is less than the Plan A Target Concentration, the reported nondetect remains.
- Data set reported with both detections and nondetections:
 - For all cases, when reported SQLs exceed maximum detected values, set the nondetected analyte concentration equal to the SQL as a proxy concentration.
- Data set reported with analytical qualifiers:
 - Set proxy analyte concentrations numerically equal to values reported for the validated, qualified data, since data validation procedures for the project indicate that data were suitable for use in project decision-making, i.e., verified data were not qualified as "rejected."

8.1.2 Chemicals of Potential Concern

Once the focused data set was prepared in accordance with the procedure previously specified, the Base Gas Station data were compared to the Plan A Target Concentrations to determine which chemicals to retain as COPC. For the Base Gas Station data, the only COPC retained for

both soil and for groundwater was benzene. The maximum values for all other detected constituents were less than the Plan A Target Concentrations specified in RG-36.

Similarly to the Base Gas Station data, the Base Service Station data were compared to the Plan A Target Concentrations to determine which chemicals to retain as COPC. For the Base Service Station data, the retained COPC are as follows:

- Soil: benzene, benzo(a)pyrene, benzo(b)fluoranthene, dibenzo (a,h)anthracene, and indeno (1,2,3-cd)pyrene.
- Groundwater: benzene, ethyl benzene, and toluene.

The maximum values for all other detected constituents were below the Plan A Target Concentrations specified in RG-36. Table 8-1 summarizes the maximum detected values for both the Base Gas Station and the Base Service Station data, and compares them with the Plan A Target Concentrations.

8.2 Exposure Assessment

The purpose of an exposure assessment is to identify potential receptors and to describe the potential pathways of exposure, as well as receptor exposure points. The exposure assessment for the Base Service Station and Base Gas Station includes a consideration of both potential on-site and off-site receptors. The exposure assessment also incorporates the findings of the 500-foot-radius field survey that was performed in accordance with TNRCC guidance (RG-175, TNRCC, 1995) to identify potential receptors and potential migration pathways for the both the Base Service Station and Base Gas Station. The results of this field survey were compiled on Figure 8-1 and are discussed within these sections related to exposure assessment.

8.2.1 Exposure Assessment Characterization

As shown on Figure 2-2, the Base Service Station and Base Gas Station are located within 400 feet of one another. The site conditions that relate to the potential for human exposure to the released contaminants are essentially the same for the Base Service Station and Base Gas Station. As such, this discussion of exposure assessment for the two areas is combined.

8.2.1.1 Site Conditions

The Base Service Station is currently vacant. The four 10,000-gallon fiberglass USTs, one 600-gallon waste oil tank, and fuel dispensers have been removed. The service bays (Building 1518,

**Identification of Chemicals of Potential Concern
Assessment Report
Base Gas Station and Base Service Station
NAS Fort Worth
Carswell Field, Texas**

Constituent	Base Gas Station				Base Service Station			
	Groundwater		Soil		Groundwater		Soil	
	Max Value (mg/L)	Plan A* (mg/L)	Max Value (mg/kg)	Plan A* (mg/kg)	Max Value (mg/L)	Plan A* (mg/L)	Max Value (mg/kg)	Plan A* (mg/kg)
Acenaphthene	0.0055	2.19	0.059	314	0.454	2.19	0.67	314
Anthracene	0.0021	3.65	ND	13	ND	3.65	0.629	13
Benzene	2.9	0.0294	0.94	0.74	13	0.0294	14	0.74
Benzo (a) Pyrene	ND	0.00017	ND	0.0877	ND	0.00017	2.57	0.0877
Benzo (b) Fluoranthene	ND	0.00117	ND	0.877	ND	0.00117	2.5	0.877
Chlorobenzene	0.012	NA	ND	NA	ND	NA	ND	NA
Chrysene	0.000099	0.117	0.0031	7.2	ND	0.117	2.74	7.2
Dibenzo (a,h) Anthracene	ND	0.000117	ND	0.0877	ND	0.000117	0.128	0.0877
Dichlorobenzene (1,2) (-o)	0.042	3.29	3.6	1140	ND	3.29	ND	1140
Dichlorobenzene (1,4) (-p)	ND	0.355	0.49	123	ND	0.355	ND	123
Ethyl benzene	0.16	3.65	1.5	835	5.5	3.65	118	835
Fluoranthene	0.00017	1.46	0.0081	156	ND	1.46	6.24	156
Fluorene	0.012	1.46	0.0021	247	ND	1.46	ND	247
Ideno (1,2,3-cd) Pyrene	ND	0.00117	0.0071	0.877	ND	0.00117	1.39	0.877
Lead	ND	NA	36.8	NA	0.0189	NA	15	NA
MTBE	0.038	NA	0.00095	NA	18.6	NA	ND	NA
Naphthalene	0.24	1.46	2.7	389	0.583	1.46	36	389
Nitrate/Nitrite	0.34	NA	ND	NA	ND	NA	ND	NA
Phenanthrene	0.0048	NA	0.029	NA	ND	NA	1.78	NA
Pyrene	ND	1.1	ND	99	ND	1.1	4.34	99
Toluene	0.018	7.3	0.02	503	25.2	7.3	287	503
Xylene (mixed isomers)	0.23	73	2.6	968	14	73	960	968

* Plan A concentrations are reported based on beneficial groundwater use category II and soil levels that are the more restrictive of groundwater protective and health-based concentrations
Bold values indicate maximum measured concentrations that exceed Plan A levels

Figure 2-2) and the concrete fuel islands and awnings are still in place. The majority of the area is paved, with the exception of the UST excavation area. Following the removal of the USTs, the excavated soil was placed back into the excavation. The area was capped with a high-density polyethylene (HDPE) liner, covered with clean fill, and currently has vegetative cover (grass).

The Base Gas Station is also currently vacant. All ASTs and operations equipment have been removed. Stained soils from the AST area were not excavated during demolition of the ASTs and ancillary facilities. Soil from two test pits, which were dug in association with soil sampling, was returned to the excavation. The area is currently covered with gravel.

The geology and hydrogeology for the area are described in Sections 2.4 and 2.5, respectively. In general, silt and clay with varying amounts of sand and gravel occur at the land surface down to depths of 5 to 20 feet. Underlying the silt and clay is a sand and gravel unit that normally increases in grain size with increasing depth. The sand deposits are fine-to coarse-grained and composed predominantly of quartz grains. Gravel is mostly limestone and fossilized limestone shell fragments ranging in size from fine to cobbles. At the Base Service Station, surface soils have been impacted by BTEX and typical aromatic and polycyclic petroleum hydrocarbon fuel constituents and subsurface soils have been impacted by BTEX and MTBE (Appendix A). Only three surface soil samples were collected at the Base Gas Station; these three samples had detectable levels of fluorene, lead, naphthalene, and toluene. Subsurface soils at the Base Gas Station have been impacted by BTEX and typical petroleum hydrocarbon fuel constituents.

As discussed in Section 2.5, the two aquifers beneath the NAS Fort Worth site are the Quaternary alluvium aquifer and the aquifer in the Paluxy Formation. These aquifers are separated by an aquitard of predominantly dry limestone of the Goodland and Walnut Formations. It is assumed that this aquitard creates a barrier from downward migration from the Quaternary to the Paluxy in the vicinity of the Base Service Station and Base Gas Station. Analysis of samples gathered from the Quaternary alluvium aquifer beneath and downgradient of the Base Service Station reveals detectable quantities of BTEX, acenaphthene, naphthalene, MTBE, and lead. Analysis of samples gathered from the same aquifer beneath and downgradient of the Base Gas Station reveal detectable quantities of BTEX, acenaphthene, anthracene, chlorobenzene, chrysene, 1,2-dichlorobenzene, fluoranthene, fluorene, MTBE, naphthalene, and phenanthrene.

Groundwater flow in the Quaternary alluvium aquifer beneath the station is northeast and east toward the Trinity River (Figures 6-1 and 6-2, and Figure 8 of Appendix A). Previous reporting

indicates that impacted groundwater is discharging from the Base Service Station into the ditch along Military Parkway, which ultimately drains to the Trinity River. Groundwater from both the Base Service Station and the Base Gas Station discharges into the Trinity River.

Surface water drainage across the Gas Station and the Base Service Station is from west to east. Formerly a culvert and ditch system were located along the Base Service Station on the west side of Military Parkway; this drainage system discharges into the Trinity River. Sediment samples collected from this drainage system did not have detectable concentrations of BTEX constituents. Fuel discharge to the ditch has not been reported since 1993. Petroleum hydrocarbons were not detected downstream of the surface water sample point SW-2, which is closest to the discharge point.

Currently, a ditch and culvert system, which collects runoff from the Base Service Station and Base Gas Station, runs along the northern edge of Davidson Drive before crossing under the intersection of Davidson and Military Parkway, where it discharges into the oil/water separator located at the southeast corner of this intersection (Figures 11 and 12, Appendix A). The surface water entering the oil/water separator is discharged into the Trinity River. Another surface drainage ditch, which collects surface water from the Base Gas Station, is located along Warehouse Street. This ditch discharges into a culvert that drains into the drainage system along the north side of Davidson Drive.

Subsurface utilities in the vicinity of the Base Service Station and Base Gas Station are shown on Figure 5-1. Soil samples were collected along the length of the subsurface utilities (Figure 4-1) to determine if the utilities are providing horizontal conduits for hydrocarbon migration from the Base Gas Station to the Base Service Station. No phase-separated hydrocarbons were visually observed or detected by field screening methods during the investigation of the horizontal conduits.

8.2.1.2 Land Use

On-Site Land Use. The Base Service Station and Base Gas Station are located on a military installation. Access to the station is limited to naval air station residents, workers, and approved visitors. The Base Service Station is currently unoccupied. However, future plans may include conversion of the Base Service Station into a retail service station. The land at the Base Gas Station site is vacant and there are no future plans for this location.

The surrounding on-site land is utilized for warehouse operations, business operations, and residential uses. Figure 8-1 shows the land usage of the surrounding 500-foot radius around the Base Service Station and Base Gas Station. The area to the south of both the Base Service Station and Base Gas Station is occupied by warehouses (Buildings 1251, 1236, and 1231) and a hazardous materials storage area (Buildings 1269 and 1270). Building 1241 currently houses a thrift store. Building 1231 formerly housed the Base Exchange and is now used for storage.

To the east of the Base Gas Station is a convenience store in Building 1275. To the east of the Base Service Station is a large open grass and tree covered area and the Trinity River. The area at the southeast corner of Davidson Drive and Military Parkway contains an oil/water separator for surface water treatment and a picnic area.

To the west of the Base Gas Station are Buildings 1194 and 1191, which are used for vehicle maintenance. To the northeast of the Base Gas Station at the northeast corner of the intersection of Desert Storm Road and Davidson Drive is Building 1500, which is an abandoned bank facility.

To the north of the Base Gas Station and the west of the Base Service Station are dormitories that house military personnel. The dormitories are located in Buildings 1520, 1521, 1522, 1523, 1524, and 1525.

There are no wildlife sanctuaries, wetlands, or agricultural areas located within the 500-foot facility radius.

Off-Site Land Use. The land uses west of the base are predominantly residential and industrial. These include single-family residences, commercial centers, Air Force Plant No. 4, and an industrial complex in White Settlement.

The predominant development south of the Base is the commercial area located at the Interstate 30 and State Highway 183 interchange. This area includes a discount retail center, a regional shopping mall, and a convenience store.

Various types of residential development are in place southeast of the Base, north of Interstate 30. South of River Oaks Boulevard and Roaring Springs Road are country club estates and upscale townhouses. Further south are middle- to upper-income, single-family housing, and

multi-family units mixed with commercial office development. Single-family housing is also found on the eastern side of the base, from the Kings Branch housing tract north to Meandering Road.

Public/recreational land uses occur north of the base, surrounding Lake Worth. Public access along the southern shore of Lake Worth is currently restricted due to NAS Fort Worth job activities. A fish hatchery, YMCA camp, and private recreation lands occur along the West Fork of the Trinity River, northeast of the Base.

8.2.1.3 Water Use

A visual field survey did not identify any registered or unregistered water wells within the 500-foot radius of either facility. A water well survey of a half-mile radius revealed two located water wells, two partially numbered water wells, and two unnumbered water wells. The water well survey is included as Appendix H. Three of the wells were located northeast of the site, just inside the half-mile radius. These wells are screened in the Paluxy formation. One of the wells may be used by a commercial business; the use of the other is unknown.

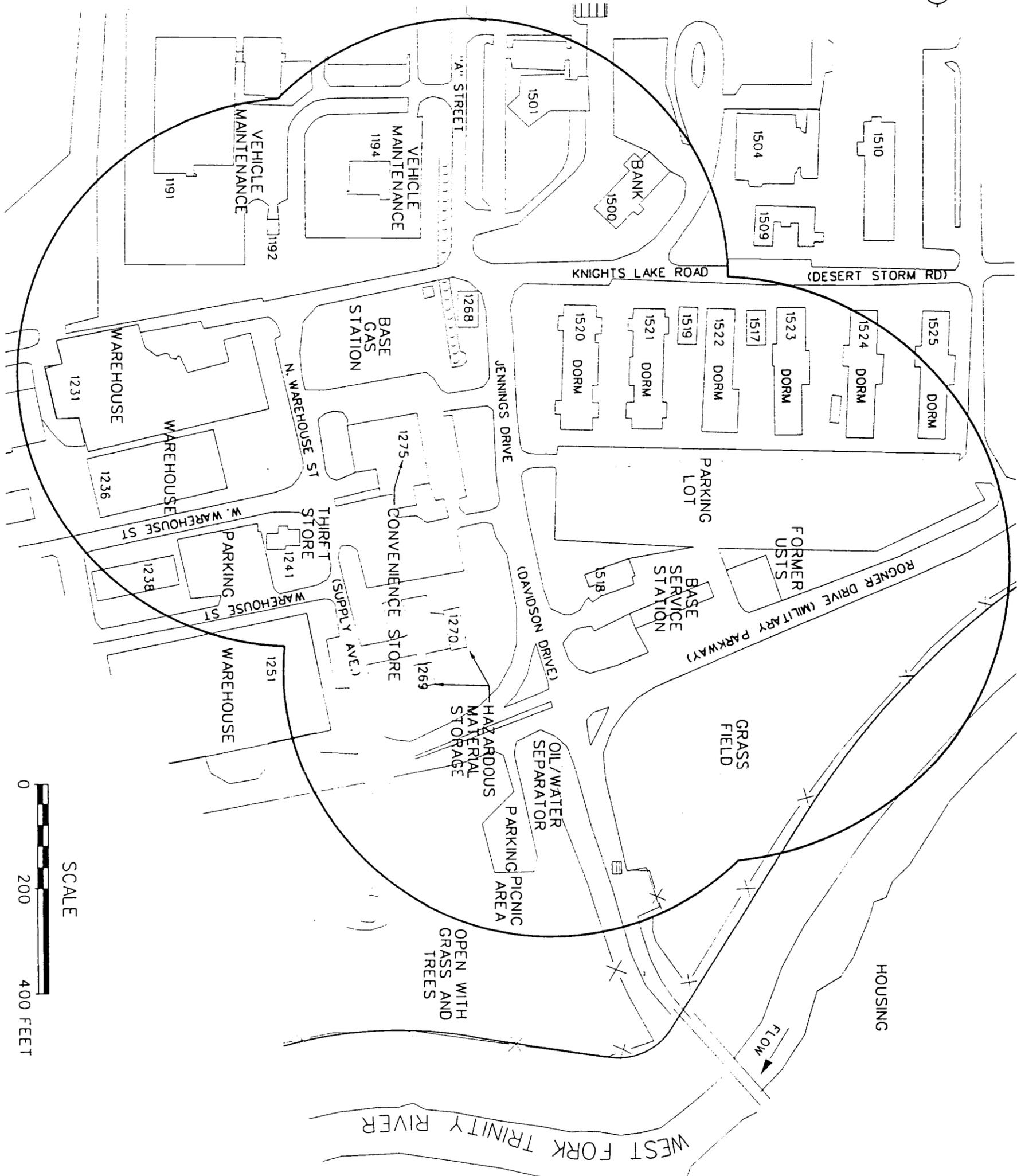
NAS Fort Worth and all of Tarrant County are located within the Trinity River watershed. Surface water resources adjacent to the station include the Trinity River and Lake Worth, which is located on the northern boundary of the Base and is upstream and uphill of the Base Service Station and Base Gas Station.

The amount of water the Trinity River receives is controlled by the watershed runoff from impervious areas during storms, by releases and overflows from the series of man-made reservoirs along the forks and tributaries by natural runoff, and by the discharge of effluent from sewage treatment plants.

8.2.2 Potentially Exposed Populations

Potentially exposed on-site populations include the NAS Fort Worth station residents and approved visitors and workers. As indicated on Figure 8-1, dormitories are located within 200 feet of the Base Service Station and Base Gas Station, a convenience store is located 100 feet from the Base Gas Station, and recreation areas, warehouses, and storage buildings are located within the 500-foot radius of the Base Service Station and Base Gas Station.

329-22



- LEGEND:**
- OPEN DRAINAGE DITCH
 - () NEW NAVY STREET NAME
 - X-X- INSTALLATION BOUNDARY
 - 500 FOOT RADIUS

FIGURE 8-1
SURROUNDING LAND USE
 BASE GAS STATION/
 BASE SERVICE STATION
 NAVAL AIR STATION FORT WORTH
 FORT WORTH, TEXAS



Potentially exposed off-site populations include residents who utilize the surrounding surface water sources for recreation activities, off-site residences or commercial/industrial enterprises that use the Paluxy aquifer for a water supply, and off-site residents who may be exposed via volatilization and dust releases to ambient air. Table 8-2 summarizes the potential receptors for the Base Service Station and Base Gas Station.

Very limited information exists regarding the Paluxy Aquifer in the vicinity of NAS Fort Worth. Regional flow in the Paluxy is southeastward; however, pumping activities at locations within several miles of the station (cities of White Settlement and Samson Park) may impact the local flow. If local gradient in the Paluxy is actually toward the northeast, off-site wells identified just within the 0.5-mile radius in the water well inventory (Appendix H) may potentially be impacted. The use of these off-site wells is uncertain. One well may be used by a commercial business.

8.2.3 Exposure Pathway Analysis

Identification of exposure pathways consists of an analysis of four necessary elements:

- Source and mechanism of chemical release to the environment
- Environmental transport medium (e.g., air, soil, groundwater)
- Exposure point, i.e., a point of potential receptor contact with the contaminated medium
- An exposure route through which chemical uptake may occur.

The exposure pathway analysis is used to focus the risk assessment on those pathways that have the potential to impact human health or the environment. The primary sources of contamination are the former USTs and associated piping at the Base Service Station and the former ASTs at the Base Gas Station. The secondary sources of contamination are surface soils, subsurface soils, dissolved groundwater plume, and affected surface soils, sediments, and surface waters from both sites. Based on these primary and secondary sources, the completeness of the exposure pathways were analyzed as discussed in the following paragraphs.

Air Exposure Pathways. Pathways relative to chemical volatilization and dust releases were evaluated and it was determined that there are four potential pathways:

Table 8-2

**Identification of Potential Receptors
Assessment Report
Base Gas Station and Base Service Station
NAS Fort Worth
Carswell Field, Texas**

Base Service Station										
<i>Exposure Medium and Exposure Route</i>	Residential Population				Worker				Site Visitor	
	On-Site		Off-Site		On-Site		Off-Site			
Groundwater										
Ingestion and Dermal Contact	✓	Future	✓	Current	✓	Future	✓	Current		
Volatilization to ambient air	✓	Future			✓	Future			✓	Future
Volatilization to enclosed space	✓	Future			✓	Future			✓	Future
Soil										
Leaching to groundwater, ingestion, and dermal contact	✓	Future			✓	Current				
Volatilization and dust releases to ambient air	✓	Future	✓	Future	✓	Future	✓	Future	✓	Future
Volatilization to an enclosed space	✓	Future			✓	Future			✓	Future

Base Gas Station										
<i>Exposure Medium and Exposure Route</i>	Residential Population				Worker				Site Visitor	
	On-Site		Off-Site		On-Site		Off-Site			
Groundwater										
Ingestion and Dermal Contact	✓	Future	✓	Current	✓	Current	✓	Current		
Volatilization to ambient air	✓	Current			✓	Current			✓	Current
Volatilization to enclosed space	✓	Future			✓	Future			✓	Future
Soil										
Leaching to groundwater, ingestion, and dermal contact					✓	Current				
Volatilization and dust releases to ambient air	✓	Current	✓	Current	✓	Current	✓	Current	✓	Current
Volatilization to an enclosed space	✓	Future			✓	Future			✓	Future

Future: Indicates a future potential pathway
Current: Indicates a current complete pathway

- (1) Volatilization and dust releases to ambient air from soil, potentially affecting on-site residents and nonresidents as well as off-site receptors
- (2) Volatilization from groundwater to ambient air, potentially affecting on-site residents and nonresidents as well as off-site receptors
- (3) Volatilization from groundwater to enclosed spaces (e.g., buildings) potentially affecting on-site residents and nonresidents
- (4) Volatilization from subsurface soils to enclosed spaces potentially affecting on-site residents and nonresidents.

At the Base Service Station, these four pathways are not considered to be complete due to the installation of an HDPE liner and clean fill above the impacted soil. However, they are retained as potential future pathways.

At the Base Gas Station, the presence of gravel cover over impacted soils does not completely preclude any of these pathways. Pathways 1 and 2 are retained as current pathways. Pathway 3 is retained as a current complete pathway (convenience store, Building 1275) and Pathways 3 and 4 are retained and analyzed together as potential future pathways (future on-site building over impacted soils and groundwater). These complete pathways were quantitatively analyzed in the risk assessment as follows:

- Based on statistically-derived maximum values (i.e., representative concentrations) observed in the in situ Base Service Station and Base Gas Station soils and assuming on-site residents as receptors, air emissions from wind erosion and atmospheric dispersion were quantitatively evaluated.
- Based on statistically-derived maximum values observed in the Base Service Station and Base Gas Station groundwater samples and assuming on-site residents as receptors, air emissions from volatilization of constituents from shallow groundwater were quantitatively evaluated.
- Based on statistically-derived maximum values measured in the Base Gas Station and Base Service Station groundwater and soil samples and assuming that a building may be constructed over the site in the future, the impact of volatilization and enclosed space accumulation was evaluated.
- Based on statistically-derived maximum values measured in the Base Gas Station groundwater and soil samples and assuming the immediate downgradient convenience store (Building 1275) as the closest potential receptor, the impact of volatilization and enclosed space accumulation was evaluated.

These pathways were quantitatively analyzed using reasonable maximum exposures (RME) factors for current exposures and most likely exposure (MLE) factors for potential future exposures (GSI, 1996).

Soil Exposure Pathways. Potential pathways relative to soil exposure were evaluated and it was determined that there were two complete pathways:

- (1) Contaminants leaching from soil to groundwater and thereby potentially impacting groundwater receptors
- (2) Dermal contact and ingestion of surface soils by construction workers.

Based on statistically-derived maximum values measured in soils, the potential impact of dermal contact and ingestion of soils were evaluated for construction workers using commercial/industrial exposure factors at both the Base Service Station and the Base Gas Station. Due to cover over impacted soils at the Base Service Station (HDPE liner, fill and vegetative cover, or asphalt and concrete) and at the Base Gas Station (gravel), dermal contact and ingestion of soils by either site residents or visitors is not considered a complete current exposure pathway, although it must be retained as a potential future exposure pathway.

Off-site soils are not contaminated as a result of Base Gas Station and Base Service Station sources. Therefore, the pathway for off-site soil exposure is not considered to be a complete pathway:

The complete pathways were quantitatively analyzed in the risk assessment as follows:

- Based on statistically-derived maximum soil concentrations, a cross-media leaching model and groundwater transport model were evaluated assuming groundwater receptors.
- Based on statistically-derived maximum groundwater concentrations, exposure resulting from ingestion and dermal contact of contaminated groundwater was used employing industrial exposure factors to calculate risk to on-site workers, and RME factors to calculate risk for future potential residents.

Surface Water Exposure Pathways. Potential pathways relative to surface water exposure were evaluated and it was determined that there is one complete pathway for both the Base Service Station and Base Gas Station:

- Storm water and surface water transport of contaminated soils and sediments to the nearby surface water (i.e., North Fork of Trinity River), potentially impacting recreational users.

Groundwater Exposure Pathways. Potential pathways relative to groundwater exposure pathways were evaluated and it was determined that there is one complete pathway for both the Base Service Station and Base Gas Station:

- Groundwater transport resulting in ingestion and dermal contact of contaminated groundwater by off-site receptors (i.e., North Fork of the Trinity River).

In addition to this pathway, there is a potential pathway of downward migration of contaminants to the Paluxy Aquifer, as described in Section 8.2.2.

Pathway Analysis Summary. Figure 8-2 provides a conceptual diagram illustrating the procedures employed for predicting transport of contaminants from the source zone to the POE for air and groundwater exposure pathways. Note that fate and transport modeling is not required for direct exposure pathways, such as soil ingestion or dermal contact, where the source and exposure concentrations are equal, i.e., natural attenuation factor (NAF) = 1.

8.3 Exposure Point Concentration

The exposure point concentration is the chemical concentration at the point of human exposure. The approach taken by the Plan B risk assessment is to use the equations detailed in Figure 8-2 to model the chemical concentrations at the POE. These concentrations are then used to yield a characterization of risk to the receptor(s) by estimating the chemical intake of the receptor(s) and employing chemical-specific toxicity data. Several assumptions have been made in order to determine exposure point concentrations.

- Use of a 95 Percent Upper Confidence Limit on the Mean Concentration. Where it is appropriate to group sampling data from a particular medium (e.g., soil, water), the 95 percent upper confidence limit (UCL) on the mean concentration may be used to estimate concentrations at the source zone. The 95 percent UCL concentration is calculated as follows:

$$UCL = \bar{x}' + ts/(n^{1/2})$$

Figure 8-2
Summary of Numerical Pathway Analysis
Assessment Report
Base Gas Station and Base Service Station
NAS Fort Worth
Carswell Field, Texas

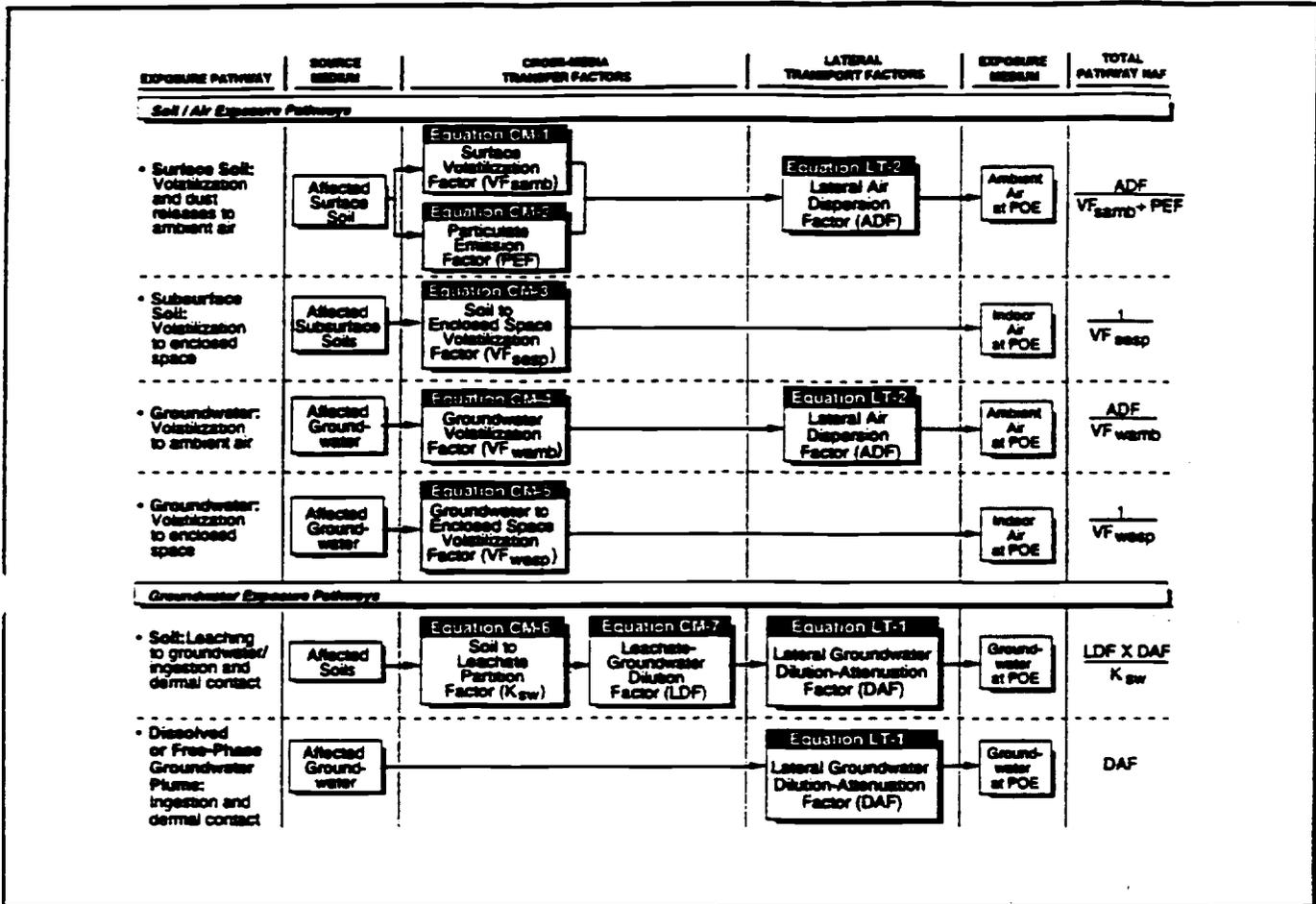
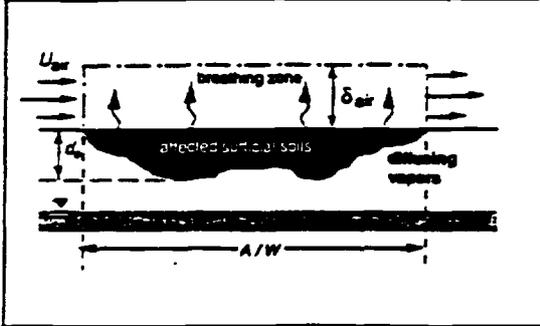


Figure 8-2 (continued)
Summary of Numerical Pathway Analysis
Assessment Report
Base Gas Station and Base Service Station
NAS Fort Worth
Carswell Field, Texas

Equation CM-1: Soil to Ambient Air Volatilization Factor (VF_{amb})



$$VF_{amb} \left(\frac{mg/m^3 - air}{mg/kg - soil} \right) = \left(\frac{A}{U_{air} \cdot W \cdot \delta_{air}} \right) \times \frac{(2 \cdot D_{eff} \cdot \theta_T \cdot K_{as})}{(3.14 \cdot \alpha \cdot \tau)^{1/2}} \times \left(\frac{kg}{10^3 g} \right) \times \left(\frac{10^4 cm^2}{m^2} \right)$$

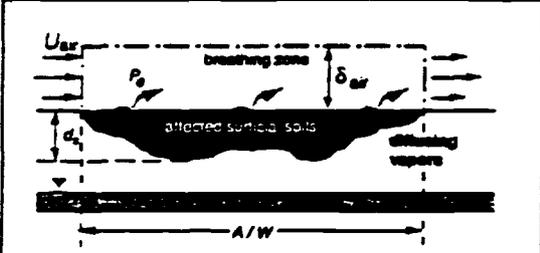
Dispersivity factor:

$$\alpha \left(\frac{cm^2}{s} \right) = \frac{D_{eff} \theta_T}{\theta_T + \frac{\rho_s}{K_{as}}}$$

Soil-air partition coefficient:

$$K_{as} \left(\frac{g - soil}{cm^3 - air} \right) = \frac{H'}{k_s} = \frac{H'}{k_{oc} f_{oc}}$$

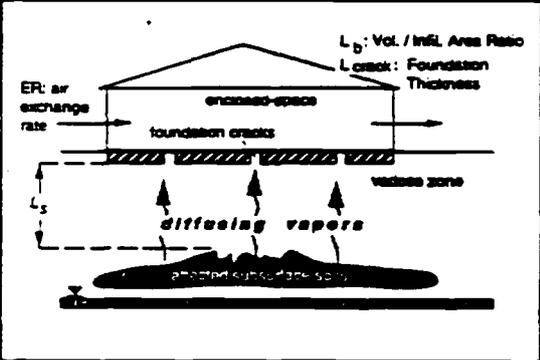
Equation CM-2: Soil Particulate Emission Factor (PEF)



$$PEF \left(\frac{mg/m^3 - air}{mg/kg - soil} \right) = Pe \times \left(\frac{A}{U_{air} \cdot W \cdot \delta_{air}} \right) \times \left(\frac{kg}{10^3 g} \right)$$

$$Pe \left(\frac{g}{m^2 \cdot s} \right) = 0.036 \times (1 - V) \times \left(\frac{U_m}{U_i} \right)^3 \times F(x) \times \left(\frac{hr}{3600s} \right)$$

Equation CM-3: Subsurface Soil to Enclosed Space Volatilization Factor (VF_{esp})



CM-3a:

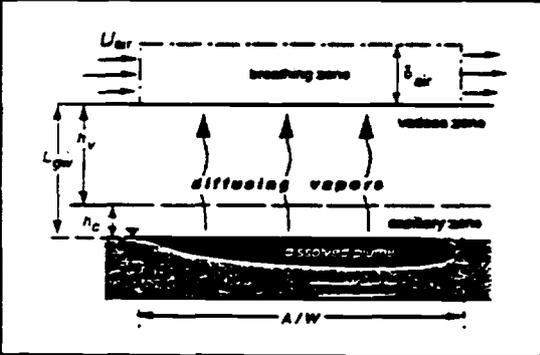
$$VF_{esp} \left[\frac{(mg/m^3 - air)}{(mg/kg - soil)} \right] = \frac{\frac{H' \rho_s}{[\theta_{ws} + k_s \rho_s + H \theta_{as}]} \left[\frac{D_{eff}^{ff} / L_B}{ER L_B} \right]}{1 + \left[\frac{D_{eff}^{ff} / L_B}{ER L_B} \right] + \left[\frac{D_{eff}^{ff} / L_B}{(D_{eff}^{ff} / L_{crack}) \eta} \right]} \times 10^3$$

or CM-3b:

$$VF_{esp} \left[\frac{(mg/m^3 - air)}{(mg/kg - soil)} \right] = \frac{\rho_s d_s}{L_B ER \tau} \times 10^3$$

whichever is less

Equation CM-4: Groundwater Volatilization Factor (VF_{wamb})



$$VF_{wamb} \left[\frac{(mg/m^3 - air)}{(mg/L - H_2O)} \right] = \frac{H'}{1 + \left[\frac{U_{air} \cdot \delta_{air} \cdot W \cdot L_{GW} \times 10^2 cm}{A \cdot D_{eff}^{ff}} \right]} \times 10^3$$

Figure 8-2 (continued)
 Summary of Numerical Pathway Analysis
 Assessment Report
 Base Gas Station and Base Service Station
 NAS Fort Worth
 Carswell Field, Texas

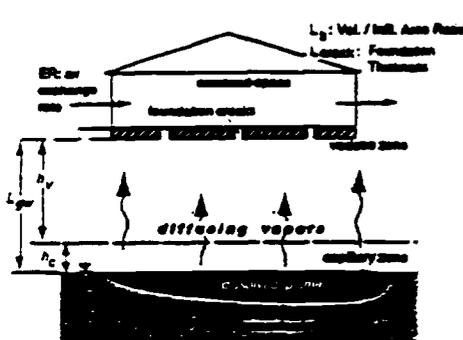
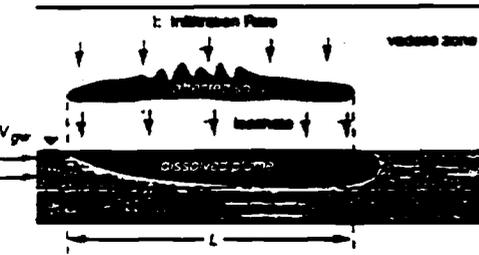
Equation CM-5: Groundwater to Enclosed Space Volatilization Factor (VF _{wesp})	
	$VF_{wesp} \left[\frac{(\text{mg}/\text{m}^3 - \text{air})}{(\text{mg}/\text{L} - \text{H}_2\text{O})} \right] = \frac{H \left[\frac{D_{ws}^{eff}/L_{GW}}{ER L_B} \right]}{1 + \left[\frac{D_{ws}^{eff}/L_{GW}}{ER L_B} \right] + \left[\frac{D_{ws}^{eff}/L_{GW}}{(D_{crack}^{eff}/L_{crack})^2} \right]} \times 10^3$
Equation CM-6: Soil Leachate Partition Factor (K _{sw}) Equation CM-7: Leachate-Groundwater Dilution Factor (LDF) Equation CM-8: Mixing Zone Depth (δ _{gw})	
	<p>CM-6: $K_{sw} \left[\frac{(\text{mg}/\text{L} - \text{H}_2\text{O})}{(\text{mg}/\text{kg} - \text{soil})} \right] = \frac{\rho_s}{\theta_{ws} + k_d \rho_s + H' \theta_{as}}$</p> <p>CM-7: LDF (dimensionless) = $1 + \frac{V_{gw} \delta_{gw}}{IL}$</p> <p>CM-8: $\delta_{gw}(\text{m}) = (2\alpha_z L)^{0.5} + h_{gw} \left[1 - \exp\left(\frac{-IL}{V_{gw} h_{gw}} \right) \right]$</p> <p>NOTE: Under Plan A, use LDF = 100. User may also choose to apply this default LDF factor under Plan B. Equation CM-8 can be used to estimate mixing zone depth under Plan B if plume thickness at source not measured.</p>
Equation CM-9: Explosive Vapors	
	$C_{ev} \left(\frac{\text{mg}}{\text{kg}} \right) = 0.25 \left(\frac{LEL(MW)}{24.45 \frac{\text{L}}{\text{mol}}} \right) \times \frac{\theta_{ws} + k_d \rho_s + H' \theta_{as}}{H' \rho_s} \times \left(\frac{\text{m}^3}{10^3 \text{L}} \right)$

Figure 8-2 (continued)
Summary of Numerical Pathway Analysis
Assessment Report
Base Gas Station and Base Service Station
NAS Fort Worth
Carswell Field, Texas

Definitions for Cross-Media Transfer Equations	
<p>D_{ei} Effective diffusivity in vadose zone soils:</p> $D_{ei} \left[\frac{cm^2}{s} \right] = D^{air} \theta_T^{1.33}$ <p>D_{ws}^{eff} Effective diffusivity above the water table:</p> $D_{ws}^{eff} \left[\frac{cm^2}{s} \right] = (h_{cap} + h_v) \left[\frac{h_{cap}}{D_{cap}^{eff}} + \frac{h_v}{D_i^{eff}} \right]^{-1}$	<p>D_{crack}^{eff} Effective diffusivity through foundation cracks:</p> $D_{crack}^{eff} \left[\frac{cm^2}{s} \right] = D^{air} \frac{\theta_{acrack}^{3.33}}{(\theta_{acrack} + \theta_{wcrack})^2} + \left[\frac{D^{wat}}{H} \right] \left[\frac{\theta_{wcrack}^{3.33}}{(\theta_{acrack} + \theta_{wcrack})^2} \right]$ <p>D_{cap}^{eff} Effective diffusivity in the capillary zone:</p> $D_{cap}^{eff} \left[\frac{cm^2}{s} \right] = D^{air} \frac{\theta_{acap}^{3.33}}{\theta_T^2} + \left[\frac{D^{wat}}{H} \right] \left[\frac{\theta_{wcrack}^{3.33}}{\theta_T^2} \right]$
<p>A Concentrated soil area (m²)</p> <p>C_{ev} Soil concentration protective of explosive vapors (mg/kg)</p> <p>d_e Thickness of affected soils (m)</p> <p>D^{air} Diffusion coefficient in air (cm²/s)</p> <p>D^{wat} Diffusion coefficient in water (cm²/s)</p> <p>ER Enclosed-space air exchange rate (1/s)</p> <p>f_{oc} Fraction of organic carbon in soil (g-C/g-soil)</p> <p>F(x) Function dependent on (U_m/U_t) (unitless)</p> <p>H Henry's law constant (cm³-H₂O)/(cm³-air)</p> <p>h_{cap} Thickness of capillary fringe (cm)</p> <p>h_{gw} Aquifer thickness (m)</p> <p>h_v Thickness of vadose zone (cm)</p> <p>I Infiltration rate of water through soil (cm/year)</p> <p>k_{oc} Carbon-water partition coefficient (cm³-H₂O/g-C)</p> <p>k_s Soil-water partition coefficient (cm³-H₂O/g-soil)</p> <p>L_B Enclosed space volume/infiltration area ratio (cm)</p> <p>L_{crack} Enclosed space foundation or wall thickness (cm)</p> <p>L_{GW} Depth to groundwater = h_{cap} + h_v (cm)</p> <p>LEL Lower Explosive Limit (ppm_v)</p> <p>L Length of soil source area parallel to groundwater flow direction (m)</p> <p>L_s Depth to affected soil (cm)</p> <p>MW Molecular weight (g/mol)</p> <p>P_e Particulate emission rate (g/cm²-s)</p> <p>U_{air} Wind speed above ground surface in ambient mixing zone (m/s)</p>	<p>U_m Mean annual wind speed at 7m height (m/s)</p> <p>U_t Equivalent threshold value of wind speed at 7m height (m/s)</p> <p>V Fraction of vegetative cover (unitless)</p> <p>V_{gw} Groundwater Darcy velocity (cm/yr)</p> <p>W Width of source area perpendicular to wind direction (m)</p> <p>δ_{air} Ambient air mixing zone height (m)</p> <p>δ_{gw} Groundwater mixing zone thickness (m)</p> <p>η Areal fraction of cracks in foundations/walls (cm²-cracks/cm²-total area)</p> <p>θ_{acap} Volumetric air content in capillary fringe soils (cm³-air/cm³-soil)</p> <p>θ_{acrack} Volumetric air content in foundation/wall cracks (cm³-air/cm³-total volume)</p> <p>θ_{as} Volumetric air content in vadose zone soils (cm³-air/cm³-soil)</p> <p>θ_T Total soil porosity (cm³-pore-space/cm³-soil)</p> <p>θ_{wcap} Volumetric water content in capillary fringe soils (cm³-H₂O/cm³-soil)</p> <p>θ_{wcrack} Volumetric water content in foundation/wall cracks (cm³-H₂O)/cm³ total volume)</p> <p>θ_{ws} Volumetric water content in vadose zone soils (cm³-H₂O/cm³-soil)</p> <p>ρ_s Soil bulk density (g-soil/cm³-soil)</p> <p>τ Averaging time for vapor flux (s)</p>

Figure 8-2 (continued)
Summary of Numerical Pathway Analysis
Assessment Report
Base Gas Station and Base Service Station
NAS Fort Worth
Carswell Field, Texas

Equation LT-1: Lateral Groundwater Dilution Attenuation Factor (DAF)	
	<p>LT-1a: Solute Transport with First-Order Decay:</p> $\frac{C(x)_i}{C_{si}} = \exp\left(\frac{x}{2\alpha_x}\left[1 - \sqrt{1 + \frac{4\lambda_i\alpha_y R_i}{v}}\right]\right) \operatorname{erf}\left(\frac{S_w}{4\sqrt{\alpha_y x}}\right) \operatorname{erf}\left(\frac{S_d}{2\sqrt{\alpha_z x}}\right)$ <p>where: $v = \frac{K \cdot i}{\theta_T}$ and $R_i = 1 + \frac{k_d \rho_s}{\theta_T}$</p> <p>LT-1b: Solute Transport with Biodegradation by Electron-Acceptor Superposition Method:</p> $C(x)_i = \left[(C_{si} + BC_i) \operatorname{erf}\left(\frac{S_w}{4\sqrt{\alpha_y x}}\right) \operatorname{erf}\left(\frac{S_d}{2\sqrt{\alpha_z x}}\right) \right] - BC_i$ <p>where: $BC_i = BC_T \times \frac{C_{si}}{\sum C_{si}}$ and $BC_T = \sum \frac{C(ea)_n}{UF_n}$</p> <p>(NOTE: $DAF = \frac{C_{si}}{C(x)_i}$ = inverse of above expression.)</p>
Equation LT-2: Lateral Air Dispersion Factor (ADF)	
	$\frac{C(x)_i}{C_{si}} = \frac{Q}{2\sigma_L \sigma_y \sigma_z} \times \exp\left(-\frac{y^2}{2\sigma_y^2}\right) \times \exp\left(-\frac{(z - \delta_{air})^2}{2\sigma_z^2}\right) \times \exp\left(-\frac{(z + \delta_{air})^2}{2\sigma_z^2}\right)$ <p>where: $Q = \frac{U_{air}(\delta_{air})(A)}{L}$</p> <p>(NOTE: $ADF = \frac{C_{si}}{C(x)_i}$ = inverse of above expression.)</p>
Definitions for Lateral Transport Equations	
<p>A Cross Sectional Area of Air Emissions Source (m²)</p> <p>α_x Longitudinal groundwater dispersivity (m)</p> <p>α_y Transverse groundwater dispersivity (m)</p> <p>α_z Vertical groundwater dispersivity (m)</p> <p>BC_i Biodegradation capacity available for constituent i</p> <p>BC_T Total biodegradation capacity of all electron acceptors in groundwater</p> <p>$C(x)_i$ Concentration of constituent i at distance x downstream of source (mg/L) or (mg/m³)</p> <p>C_{si} Concentration of constituent i in Source Zone (mg/L) or (mg/m³)</p> <p>$C(ea)_n$ Concentration of electron acceptor n in groundwater</p> <p>δ_{air} Ambient air mixing zone height (m)</p> <p>foc Fraction organic carbon in soil (g-C/g-soil)</p> <p>i Hydraulic Gradient (m/m)</p> <p>λ_i First-Order Degradation Rate (day⁻¹) for constituent i</p> <p>K Hydraulic Conductivity (m/day)</p> <p>k_d Soil-water partition coefficient for ionic compounds (cm³-H₂O/g-soil)</p> <p>K_{oc} Carbon-water partition coefficient (cm³-H₂O/g-C)</p>	<p>k_d Soil-water partition coefficient (cm³-H₂O/g-soil)</p> <ul style="list-style-type: none"> • For organics: $k_d = K_{oc} \cdot foc$ • For inorganics or ionizing organics: k_d = pH-dependent k_d value <p>L Length of Air Emissions source (m) parallel to wind direction</p> <p>σ_y Transverse air dispersion coefficient (m)</p> <p>σ_z Vertical air dispersion coefficient (m)</p> <p>ρ_s Soil bulk density (g-soil/cm³-soil)</p> <p>θ_T Total soil porosity (cm³-pore space/cm³-soil)</p> <p>θ_e Effective Soil Porosity</p> <p>Q Air volumetric flow rate through mixing zone (m³/s)</p> <p>R_i Constituent retardation factor</p> <p>U_{air} Wind Speed (m/sec)</p> <p>UF_n Utilization factor for electron acceptor n (i.e., mass ratio of electron acceptor to hydrocarbon consumed in biodegradation reaction)</p> <p>S_w Source Width (m)</p> <p>S_d Source Depth (m)</p> <p>v Groundwater Seepage Velocity (m/day)</p> <p>y Lateral Distance From source zone (assumed to be 0) (m)</p> <p>x Distance downgradient of source (m)</p> <p>z Height of Breathing Zone (assumed equal to δ_{air}) (m)</p>

where:

- x' is sample mean
- t is a value from Table 3, RG-36 (TNRCC, 1994a)
- s is standard deviation
- n is number of samples (population).

In accordance with guidance in RG-36, for compounds that were detected at least once in a medium greater than the SQL, and then detected in other samples at a concentration that is less than the SQL but greater than the method detection limit (MDL), a value of one-half the SQL is assumed for the nondetects in the statistical analysis rather than eliminating the nondetect results or using a value of zero.

- Use of GW Dispersivity Calculation Option. A modified Domenico model is used to model solute transport in groundwater, and the dispersivity method of Xu and Eckstein (1995) is employed to estimate dispersivity.
- Use of Estimates to Establish Groundwater Darcy Velocity and Groundwater Seepage Velocity. Groundwater velocities are estimated as:
 - Darcy $v = (k \times \text{gradient})$ where $k = \text{hydraulic conductivity (centimeters per second)}$
 - Seepage $v = (k \times \text{gradient})/\text{porosity}$.
- Use of Default Leachate Dilution Factor. As specified in RG-36 (TNRCC, 1994a), the default value for Leachate Dilution Factor (LDF) of 100 is employed.
- Use of Domenico Equation with First-Order Decay. Solute transport is estimated by use of the Domenico equation with first-order decay (see equation LT-1 in Figure 8-2).

By the use of the equations in Figure 8-2 and the assumptions previously listed, source zone concentration measurements are converted to exposure point concentrations for the various receptor groups. Appendix O contains output from the modeling software (RBCA Plan A/Plan B Spreadsheet System, GSI, 1996). Output Table 2 in Appendix O details the exposure concentrations and intake calculations for each of the complete pathways.

8.4 Estimation of Chemical Intake

Default RME parameters are specified in Table 4 of RG-36 (TNRCC, 1994a). Consistent with the guidance, when there is an actual human exposure, the RME parameters are employed to estimate contaminant dose concentrations. When exposures are quantified for potential future

exposures, the MLEs are employed. Appendix O contains output from the modeling software (RBCA Plan A/Plan B Spreadsheet System, GSI, 1996). Output Table 1 of Appendix O details each of the exposure parameters for both RME and MLE intake calculations, and Output Table 2 details the exposure concentrations and intake calculations for each of the complete pathways

8.5 Toxicity Assessment

Toxicity values for each of the chemicals of concern were employed to evaluate both cancer risk and noncancer hazard quotient. The values for reference doses and cancer slope factors were chosen from values tabulated in Table C-1 of RG-36 (TNRCC, 1994a) and are summarized in Table 8-3.

8.6 Risk Characterization

The corresponding carcinogenic risk or hazard quotient for each contaminant in each exposure pathway was determined, as well as the cumulative cancer risk and hazard index for each exposure pathway. This cumulative risk calculation accounts for the total exposure of an individual to the sum of exposures from multiple pathways. Figure 8-3 summarizes applicable target risk limits for Plan B risk assessments performed using TNRCC guidance (RG-36, TNRCC, 1994a).

Base Service Station. The cumulative baseline risk calculations for the on-site and off-site exposure pathways at the Base Service Station indicate that no current or future exposure pathway exceeds target risk levels. The results of the cumulative baseline risk calculation for the Base Service Station are summarized in Table 8-4.

Base Gas Station. The cumulative baseline risk calculations for the on-site and off-site exposure pathways at the Base Gas Station indicate that no current or future exposure pathway exceeds target risk levels. The results of the cumulative baseline risk calculation for the Base Gas Station are summarized in Table 8-5.

8.7 Uncertainty Analysis

For the most part, the input parameters relative to the exposure assessment that were selected for use in the Plan B baseline risk assessment correspond with conservative parameters specified by TNRCC (RG-36, TNRCC, 1994a). These parameters are conservative in nature and tend to overstate the actual risks posed to human health and the environment. Similarly, the site-specific characteristics are well understood and documented in the various investigations. The small

Table 8-3

**Toxicity Factors for Chemicals of Potential Concern
Assessment Report
Base Gas Station and Base Service Station
NAS Fort Worth
Carswell Field, Texas**

Constituent	CAS Number	Class	Base Gas Station						Base Service Station							
			Toxicants			Carcinogens			Toxicants			Carcinogens				
			RfC (mg/kg-day)	RfD (mg/kg-day)	SFI 1/(mg/kg-day)	Sfo 1/(mg/kg-day)	RfC (mg/kg-day)	RfD (mg/kg-day)	SFI 1/(mg/kg-day)	Sfo 1/(mg/kg-day)	RfC (mg/kg-day)	RfD (mg/kg-day)	SFI 1/(mg/kg-day)	Sfo 1/(mg/kg-day)		
Benzene	71-43-2	A	-	-	0.0291	0.029	-	-	-	-	0.0291	0.029	-	-	-	-
Benzo (a) Pyrene	50-32-8	B2	-	-	-	-	-	-	-	-	6.1	7.3	-	-	6.1	7.3
Benzo (b) Fluoranthene	205-99-2	B2	-	-	-	-	-	-	-	-	0.61	0.73	-	-	0.61	0.73
Dibenzo (a,h) Anthracene	53-70-3	B2	-	-	-	-	-	-	-	-	6.1	7.3	-	-	6.1	7.3
Ethylbenzene	100-41-4	D	-	-	-	-	-	1	0.1	-	-	-	-	-	-	-
Ideno (1,2,3-cd) Pyrene	193-39-5	B2	-	-	-	-	-	-	-	-	0.61	0.73	-	-	0.61	0.73
Toluene	108-88-3	D	-	-	-	-	-	0.4	0.2	-	-	-	-	-	-	-

RfC - reference concentration
RfD - reference dose
SFI - inhalation slope factor
Sfo - oral slope factor

Table 8-4

**Cumulative Baseline Risk Calculation for Base Service Station
Assessment Report
Base Gas Station and Base Service Station
NAS Fort Worth
Carswell Field, Texas**

CONSTITUENTS OF CONCERN		ON-SITE: RESIDENTIAL LAND USE											
		Representative Concentration		Outdoor Air: Future Exposure		Indoor Air: Future Exposure		Soil: Future Exposure (Construction Worker)		Combined Soil/Air: Future Exposure		Groundwater: Future Exposure	
CAS No.	Name	Soil (mg/kg)	Groundwater (mg/L)	Carcinogenic Risk	Hazard Quotient	Carcinogenic Risk	Hazard Quotient	Carcinogenic Risk	Hazard Quotient	Carcinogenic Risk	Hazard Quotient	Carcinogenic Risk	Hazard Quotient
71-43-2	Benzene	1.90E-02	7.80E-01	4.00E-08	6.30E-03	1.80E-06	2.90E-01	4.80E-10	4.10E-08	4.70E-07	6.30E-03	3.80E-05	NA
50-32-8	Benzo(a)Pyrene	1.70E+00	NA	NA	NA	NA	NA	9.90E-06	9.90E-06	9.90E-06	NA	NA	NA
205-99-2	Benzo(b)Fluoranthene	5.00E-02	NA	NA	NA	NA	NA	5.60E-07	5.60E-07	5.60E-07	NA	NA	NA
53-70-3	Dibenzo(a,h)Anthracen	4.00E-02	NA	NA	NA	NA	NA	2.40E-07	2.40E-07	2.40E-07	NA	NA	NA
100-41-4	Ethylbenzene	2.40E-01	6.30E-01	NA	1.60E-05	NA	3.50E-04	4.70E-07	4.70E-07	4.70E-07	3.80E-05	NA	8.30E-02
193395	Indeno(1,2,3,c,d)Pyrene	7.90E-01	NA	NA	8.90E-05	NA	2.40E-03	1.30E-05	1.30E-05	1.30E-05	1.00E-04	NA	8.70E-02
108-88-3	Toluene	2.60E-01	1.30E+00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
				4.0E-8	6.4E-3	1.8E-6	2.9E-1	1.1E-5	3.5E-5	1.1E-5	6.4E-3	3.8E-5	1.7E-1

Cumulative Values:

■ indicates risk level exceeding target risk

CONSTITUENTS OF CONCERN		OFF-SITE: RESIDENTIAL LAND USE											
		Representative Concentration		Outdoor Air: Current Exposure		Groundwater: Current Exposure		Outdoor Air: Future Exposure		Groundwater: Future Exposure		Cumulative Values	
CAS No.	Name	Soil (mg/kg)	Groundwater (mg/L)	Carcinogenic Risk	Hazard Quotient	Carcinogenic Risk	Hazard Quotient	Carcinogenic Risk	Hazard Quotient	Carcinogenic Risk	Hazard Quotient	Carcinogenic Risk	Hazard Quotient
71-43-2	Benzene	1.90E-02	7.80E-01	1.60E-08	7.50E-04	6.80E-09	NA	1.80E-06	2.90E-01	4.80E-10	4.10E-08	4.70E-07	6.30E-03
50-32-8	Benzo(a)Pyrene	1.70E+00	NA	NA	NA	NA	NA	9.90E-06	9.90E-06	9.90E-06	NA	NA	NA
205-99-2	Benzo(b)Fluoranthene	5.00E-02	NA	NA	NA	NA	NA	5.60E-07	5.60E-07	5.60E-07	NA	NA	NA
53-70-3	Dibenzo(a,h)Anthracen	4.00E-02	NA	NA	NA	NA	NA	2.40E-07	2.40E-07	2.40E-07	NA	NA	NA
100-41-4	Ethylbenzene	2.40E-01	6.30E-01	NA	1.10E-04	NA	4.10E-02	4.70E-07	4.70E-07	4.70E-07	3.80E-05	NA	8.30E-02
193395	Indeno(1,2,3,c,d)Pyrene	7.90E-01	NA	NA	6.87E-04	NA	4.30E-02	1.30E-05	1.30E-05	1.30E-05	1.00E-04	NA	8.70E-02
108-88-3	Toluene	2.60E-01	1.30E+00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
				1.6E-8	7.6E-4	6.8E-9	8.4E-2	1.1E-5	3.5E-5	1.1E-5	6.4E-3	3.8E-5	1.7E-1

Cumulative Values:

■ indicates risk level exceeding target risk

Table 8-5

**Cumulative Baseline Risk Calculation for Base Gas Station
Assessment Report
Base Gas Station and Base Service Station
NAS Fort Worth
Carswell Field, Texas**

CONSTITUENTS OF CONCERN		ON-SITE: RESIDENTIAL LAND USE											
		Representative Concentration		Outdoor Air: Current Exposure		Indoor Air: Future Exposure		Soil: Future Exposure (Construction Worker)		Combined Soil/Air: Current Exposure		Groundwater: Future Exposure	
CAS No.	Name	Soil (mg/kg)	Groundwater (mg/L)	Carcinogenic Risk	Hazard Quotient	Carcinogenic Risk	Hazard Quotient	Carcinogenic Risk	Hazard Quotient	Carcinogenic Risk	Hazard Quotient	Carcinogenic Risk	Hazard Quotient
71-43-2	Benzene	2.7E-3	3.4E-2	1.1E-8	5.2E-4	6.1E-8	9.8E-3	6.9E-11	0.0E+0	1.1E-8	5.2E-4	1.7E-6	0.0E+0
Cumulative Values:				1.1E-8	5.2E-4	6.1E-8	9.8E-3	6.9E-11	0.0E+0	1.1E-8	5.2E-4	1.7E-6	0.0E+0

■ indicates risk level exceeding target risk

CONSTITUENTS OF CONCERN		OFF-SITE: RESIDENTIAL LAND USE					
		Representative Concentration		Outdoor Air: Current Exposure		Groundwater: Current Exposure	
CAS No.	Name	Soil (mg/kg)	Groundwater (mg/L)	Carcinogenic Risk	Hazard Quotient	Carcinogenic Risk	Hazard Quotient
71-43-2	Benzene	2.7E-3	3.4E-2	2.5E-10	1.2E-5	2.5E-51	0.0E+0
Cumulative Values:				2.5E-10	1.2E-5	2.5E-51	0.0E+0

■ indicates risk level exceeding target risk

range of uncertainty inherent in such site characteristics as soil porosity or average wind speed have a negligible impact on the cumulative risk calculations.

However, there are several parameters that were employed in the risk assessment that add variability to the outcome of the risk assessment, depending on how the parameters are employed and the assumptions inherent in their use. These parameters are tabulated in the sensitivity analysis detailed in Tables 8-6 and 8-7, and are described as follows:

Alternative 1. Use of Maximum Values Instead of 95 Percent UCL Concentrations. The use of concentration values that represent the 95 percent UCL on the mean concentrations of chemicals of concern tends to be somewhat less conservative than the use of maximum detected concentrations. The variability inherent in this approach was analyzed and is reported in Table 8-6 (Base Service Station) and Table 8-7 (Base Gas Station).

Alternative 2. No Consideration of the Effects of Bioattenuation. Bioattenuation was considered in the Base case risk calculation since solute transport is estimated by use of the Domenico equation with first-order decay (see equation LT-1 in Figure 8-2). A more conservative approach would be to perform the risk calculation with no consideration for bioattenuation. This was done by using the Domenico equation with dispersion only. The variability inherent in this approach was analyzed and is reported in Table 8-6 (Base Service Station) and Table 8-7 (Base Gas Station).

Base Service Station. As demonstrated by the sensitivity analysis results in Table 8-6, the variability of the two detailed parameters does have a measurable effect on the risk calculations. If maximum concentrations are employed rather than 95 percent UCL on the mean values, six pathways exceed target risk values:

- The on-site potential future pathway of air emissions from wind erosion and atmospheric dispersion exceeds target noncancer risk levels.
- The on-site potential future pathway that consists of volatilization from groundwater and soils to enclosed spaces (e.g., buildings), potentially affecting on-site residents and nonresidents, exceeds target risk levels for both cancer risk and noncancer risk.
- The on-site potential future pathway of soil ingestion/dermal contact (construction worker scenario) exceeds target cancer risk levels.

Table 8-6

Sensitivity Analysis to Baseline Risk Calculation for Base Service Station
 Assessment Report
 Base Gas Station and Base Service Station
 NAS Fort Worth
 Carswell Field, Texas

CONSTITUENTS OF CONCERN		Representative Concentration		ON-SITE: RESIDENTIAL LAND USE															
				Outdoor Air: Future Exposure		Indoor Air: Future Exposure		Soil: Future Exposure (Construction Worker)		Combined Soil/Air: Future Exposure		Groundwater: Future Exposure							
CAS No.	Name	Soil (mg/kg)	Groundwater (mg/L)	Target Risk: 1E-04	Hazard Quotient	Target HO = 1	Target Risk: 1E-04	Hazard Quotient	Target HO = 1	Target Risk: 1E-04	Hazard Quotient	Target HO = 1	Target Risk: 1E-06	Hazard Quotient	Target HO = 1	Target Risk: 1E-04	Hazard Quotient	Target HO = 1	
71-43-2	Benzene	1.90E-02	7.80E-01	4.00E-08	6.30E-03	1.80E-06	1.80E-06	2.90E-01	4.80E-10	4.10E-08	3.80E-05	3.80E-05	4.10E-08	9.90E-06	9.90E-06	3.80E-05	NA	NA	NA
50-32-8	Benzo(a)Pyrene	1.70E+00	NA	NA	NA	NA	NA	NA	9.90E-06	9.90E-06	5.60E-07	5.60E-07	9.90E-06	5.60E-07	5.60E-07	NA	NA	NA	NA
205-99-2	Benzo(b)Fluoranthene	5.00E-02	NA	NA	NA	NA	NA	NA	2.40E-07	2.40E-07	2.20E-05	2.20E-05	2.40E-07	2.40E-07	2.40E-07	NA	NA	NA	NA
53-70-3	Dibenzo(a,h)Anthracene	4.00E-02	NA	NA	NA	NA	NA	NA	4.70E-07	4.70E-07	1.30E-05	1.30E-05	4.70E-07	4.70E-07	4.70E-07	NA	NA	NA	8.30E-02
100-41-4	Ethylbenzene	2.40E-01	6.30E-01	NA	1.60E-05	NA	NA	3.50E-04	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	8.30E-02
193395	Indeno(1,2,3-c,d)Pyren	7.90E-01	NA	NA	8.90E-05	NA	NA	2.40E-03	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	8.70E-02
108-88-3	Toluene	2.60E-01	1.30E+00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	8.70E-02

Base Case Cumulative Risk Values

Alternative 1: Maximum Concentration Cumulative Risk Values

Alternative 2: No Bioattenuation Cumulative Risk Values

■ indicates risk level exceeding target risk

CONSTITUENTS OF CONCERN		Representative Concentration		OFF-SITE: RESIDENTIAL LAND USE															
				Outdoor Air: Current Exposure		Groundwater: Current Exposure													
CAS No.	Name	Soil (mg/kg)	Groundwater (mg/L)	Target Risk: 1E-06	Hazard Quotient	Target HO = 1	Target Risk: 1E-06	Hazard Quotient	Target HO = 1	Target Risk: 1E-06	Hazard Quotient	Target HO = 1	Target Risk: 1E-06	Hazard Quotient	Target HO = 1	Target Risk: 1E-06	Hazard Quotient	Target HO = 1	
71-43-2	Benzene	1.90E-02	7.80E-01	1.60E-08	7.50E-04	6.80E-09	6.80E-09	6.80E-09	6.80E-09	6.80E-09	6.80E-09	6.80E-09	6.80E-09	6.80E-09	6.80E-09	6.80E-09	6.80E-09	6.80E-09	6.80E-09
50-32-8	Benzo(a)Pyrene	1.70E+00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
205-99-2	Benzo(b)Fluoranthene	5.00E-02	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
53-70-3	Dibenzo(a,h)Anthracene	4.00E-02	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
100-41-4	Ethylbenzene	2.40E-01	6.30E-01	NA	1.10E-04	NA	NA	4.10E-02	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
193395	Indeno(1,2,3-c,d)Pyren	7.90E-01	NA	NA	6.87E-04	NA	NA	4.30E-02	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
108-88-3	Toluene	2.60E-01	1.30E+00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Base Case Cumulative Risk Values

Alternative 1: Maximum Concentration Cumulative Risk Values

Alternative 2: No Bioattenuation Cumulative Risk Values

■ indicates risk level exceeding target risk

Table 8-7

Sensitivity Analysis to Baseline Risk Calculation for Base Gas Station
 Assessment Report
 Base Gas Station and Base Service Station
 NAS Fort Worth
 Carswell Field, Texas

CONSTITUENTS OF CONCERN		Representative Concentration		ON-SITE: RESIDENTIAL LAND USE					
CAS No.	Name	Soil (mg/kg)	Groundwater (mg/L)	Outdoor Air: Current Exposure	Indoor Air: Future Exposure	Soil: Future Exposure (Construction Worker)	Combined Soil/Air: Current Exposure	Groundwater: Future Exposure	
				Target Risk: 1E-06 Hazard Quotient Carcinogenic Risk	Target Risk: 1E-04 Hazard Quotient Carcinogenic Risk	Target Risk: 1E-04 Hazard Quotient Carcinogenic Risk	Target Risk: 1E-06 Hazard Quotient Carcinogenic Risk	Target Risk: 1E-04 Hazard Quotient Carcinogenic Risk	
71-43-2	Benzene	2.7E-3	3.4E-2	1.1E-8 5.2E-4	6.1E-8 9.6E-3	6.9E-11 0.0E+0	1.1E-8 5.2E-4	1.7E-6 0.0E+0	
Base Case Cumulative Risk Values				1.1E-8	6.1E-8	6.9E-11	1.1E-8	1.7E-6	
Alternative 1: Maximum Concentration Cumulative Risk Values				3.0E-6	1.4E-1	2.4E-8	3.0E-6	1.4E-4	
Alternative 2: No Bioattenuation Cumulative Risk Values				3.0E-6	1.4E-1	2.4E-8	3.0E-6	1.4E-4	

■ indicates risk level exceeding target risk

CONSTITUENTS OF CONCERN		Representative Concentration		OFF-SITE: RESIDENTIAL LAND USE					
CAS No.	Name	Soil (mg/kg)	Groundwater (mg/L)	Outdoor Air: Current Exposure	Indoor Air: Future Exposure	Soil: Future Exposure (Construction Worker)	Combined Soil/Air: Current Exposure	Groundwater: Future Exposure	
				Target Risk: 1E-06 Hazard Quotient Carcinogenic Risk	Target Risk: 1E-04 Hazard Quotient Carcinogenic Risk	Target Risk: 1E-04 Hazard Quotient Carcinogenic Risk	Target Risk: 1E-06 Hazard Quotient Carcinogenic Risk	Target Risk: 1E-04 Hazard Quotient Carcinogenic Risk	
71-43-2	Benzene	2.7E-3	3.4E-2	2.5E-10 1.2E-5	2.5E-51 0.0E+0	2.4E-8 0.0E+0	3.0E-6 1.4E-1	1.4E-4 0.0E+0	
Base Case Cumulative Risk Values				2.5E-10	2.5E-51	2.4E-8	3.0E-6	1.4E-4	
Alternative 1: Maximum Concentration Cumulative Risk Values				6.7E-8	3.2E-3	2.2E-49	0.0E+0	0.0E+0	
Alternative 2: No Bioattenuation Cumulative Risk Values				6.7E-8	3.2E-3	3.6E-6	0.0E+0	0.0E+0	

■ indicates risk level exceeding target risk

- The on-site potential future pathway of ingestion and dermal contact with groundwater exceeds target risk levels for both cancer risk and noncancer risk.
- The off-site current pathway of volatilization and dust releases to ambient air from soil, potentially affecting off-site receptors, exceeds target cancer risk levels.
- The off-site current pathway of ingestion and dermal contact with groundwater exceeds target noncancer risk levels.

If bioattenuation is not considered, one pathway exceeds target risk values:

- The off-site current pathway of ingestion and dermal contact with groundwater exceeds target cancer risk levels.

Base Gas Station. As demonstrated by the sensitivity analysis results in Table 8-7, the variability of the two detailed parameters does have a measurable effect on the risk calculations. If maximum concentrations are employed rather than 95 percent UCL on the mean values, four pathways exceed target risk values:

- The on-site current pathway of air emissions from wind erosion and atmospheric dispersion exceeds target cancer risk levels.
- The on-site potential future pathway that consists of volatilization from groundwater and soils to enclosed spaces (e.g., buildings), potentially affecting on-site residents and nonresidents, exceeds target noncancer risk levels.
- The on-site potential future pathway of soil ingestion/dermal contact (construction worker scenario) exceeds target cancer risk levels.
- The on-site potential future pathway of ingestion and dermal contact with groundwater exceeds target cancer risk levels.

If bioattenuation is not considered, one pathway exceeds target risk values:

- The off-site current pathway of ingestion and dermal contact with groundwater exceeds target cancer risk levels.

Justification of Approach. While the detailed factors do have a significant impact on the quantitative risk assessment, the Base case approach is justified as follows:

Use of 95 Percent UCL on the Mean. The statistically-derived concentration values that were employed in the Base case approach are protective of human health because they more accurately represent site conditions than do maximum values. Benzene is the risk driver for most of the pathways, and the sample size (greater than 10) and distribution (lognormal) warrant the statistical approach as provided in RG-36 (TNRCC, 1994a). Also, because benzene is the risk driver for most pathways, the use of bioattenuation in the solute transport model is warranted because the bioattenuation of benzene in the environment is well-documented. A conservative half-life of 720 days was selected for benzene. The half-lives for all the constituents are documented in the model output provided in Appendix O, but it should be noted that bioattenuation of all of the organic compounds comprising the chemicals of concern for both the Base Service Station and Base Gas Station is well-documented.

8.8 Special Considerations

There are two compelling special considerations that must be qualitatively considered in order to fully understand and use the results from the quantitative risk assessment:

- **Surface Water Pathway.** In Section 8.2.3, a potential pathway was identified that consists of storm water and surface water transport of contaminated soils and sediments to the nearby surface water (i.e., North Fork of Trinity River), potentially impacting recreational users. It should be noted that surface water transport occurs in a network of ditches on the site, so that intermittently during discharge events, these ditches could potentially be the receptor location when they contain water with concentrations of COPC.

Surface water samples collected from these ditches (see Table 7-1) demonstrate the presence of contaminants in the surface water. Analytical results from previous investigations conducted in 1993 indicate detections of BTEX compounds in the surface water immediately downstream of a culvert along Military Parkway. Surface water samples farther downstream in the ditch had no detections of COPC. Since the ditches are only intermittently a possible POE, the North Fork of the Trinity River itself is considered to be the POE for contaminated groundwater and surface water in the quantitative risk assessment.

- **Stained Surface Soils at Base Gas Station.** Certain surface soils at the Base Gas Station site were reported to be stained during demolition of the ASTs in 1994 (Appendix G). During inspection of the site in 1996, there was no visible staining of the surface soils. Sampling of these stained areas was not done during the August 1996 investigation conducted by IT because the location of the stained soils could not be identified.

8.9 Proposed Cleanup Levels

Proposed cleanup levels are based on the risk levels detailed in Table 8-3, which are:

- For Class A and B carcinogens, an excess lifetime cancer risk of 1.0×10^{-6} for current on-site and all off-site exposure scenarios
- For Class C carcinogens, an excess lifetime cancer risk of 1.0×10^{-5} for current on-site and all off-site exposure scenarios
- For Class A, B, and C carcinogens, an excess lifetime cancer risk of 1.0×10^{-4} for on-site future potential exposure scenarios
- For all toxicants (i.e., noncancer risk), a target hazard quotient of 1.0 for all exposure scenarios.

The final cleanup level was selected by examining the critical exposure pathway, i.e., the pathway that yields the highest risk. For both the Base Service Station and the Base Gas Station, the cumulative baseline risk calculations using the 95 percent UCL concentrations for soil and groundwater did not exceed target risk levels for cancer or noncancer risk. Based on the quantitative risk assessment, it is determined that neither impacted soils or impacted groundwater pose an unacceptable risk and no further action is required at the Base Service Station or Base Gas Station. The pathways and final recommendations for each COPC are summarized in Table 8-8.

8.10 Compliance Point

Based on the quantitative risk assessment, no further investigation or remediation is necessary at the Base Service Station or the Base Gas Station. RG-36 (TNRCC, 1994a) requires that monitoring be performed to verify the exposure assumptions and that institutional controls be considered to maintain the exposure assumptions. Therefore, it is recommended that compliance points be established within the groundwater plume to monitor the impacted groundwater. For the Base Service Station, monitoring wells BASE SERVICE STATION-B, MW-1, and MW-10 should be monitored for the COPC listed in Table 8-3. For the Base Gas Station, monitoring wells BGSMW03, BGSMW05, and BGSMW06 should be monitored for the COPC listed in Table 8-3. A subsequent request for site closure, which will evaluate the need for institutional controls, will be submitted to the TNRCC for approval.

Table 8-8

029 44

**Proposed Cleanup Levels for Chemicals of Potential Concern
Assessment Report
Base Gas Station and Base Service Station
NAS Fort Worth
Carswell Field, Texas**

Base Service Station Cleanup Levels		
Constituent	Soil Cleanup Level mg/kg	Groundwater Cleanup Level mg/L
Benzene	NFA	NFA
Benzo (a) Pyrene	NFA	NA
Benzo (b) Fluoranthene	NFA	NA
Dibenzo (a,h) Anthracene	NFA	NA
Ethylbenzene	NA	NFA
Ideno (1,2,3-cd) Pyrene	NFA	NA
Toluene	NA	NFA

Base Gas Station Cleanup Levels		
Constituent	Soil Cleanup Level mg/kg	Groundwater Cleanup Level mg/L
Benzene	NFA	NFA

NA - not applicable

NFA - no further action required under base case assumptions

329 45

FINAL PAGE

ADMINISTRATIVE RECORD

FINAL PAGE

FINAL PAGE

ADMINISTRATIVE RECORD

FINAL PAGE